NEOM نيوم

Book 2- Data Collection Results

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	Prepared by	Reviewed by	Approved by
Name	Maram Ibrahim		Saeid Shadvali
Job Title	Project Engineer		Project Manager
Signature	FICHTNER Digitally signed by Ibrahim, Meram Date: 2024.07.18 16:41:08 +02'00'		FICHTNER Digitally signed by Shadvali, Saeid Date: 2024.07.18 16:15:33 +02'00'
Date			

NEOM Document approval

	Reviewed by	**Approved by**
Name		
Job Title		

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1 Site Appreciation Report

1.1 Site Topographical Study

A site visit by the local design engineer was conducted for the four potential sites of this project identified in the main report, namely:

- North: 27°35'53.93"N, 35°32’04.49"E

This site is conveniently accessible via Highway 55. The weather conditions during the visit were rainy, with temperatures ranging from 20 to 22 °C.

Figure 1: Site Visit Locations

Source: OpenStreetMap.org

1.1.1 Site 1: NIC-A-003-04

Firstly, the project location for Site 1 is conveniently situated approximately 900 meters west of Highway 55, allowing easy access. Entry to the site can be gained from the southbound direction of the highway through a temporary dirt road, which can accommodate large trucks carrying heavy loads.

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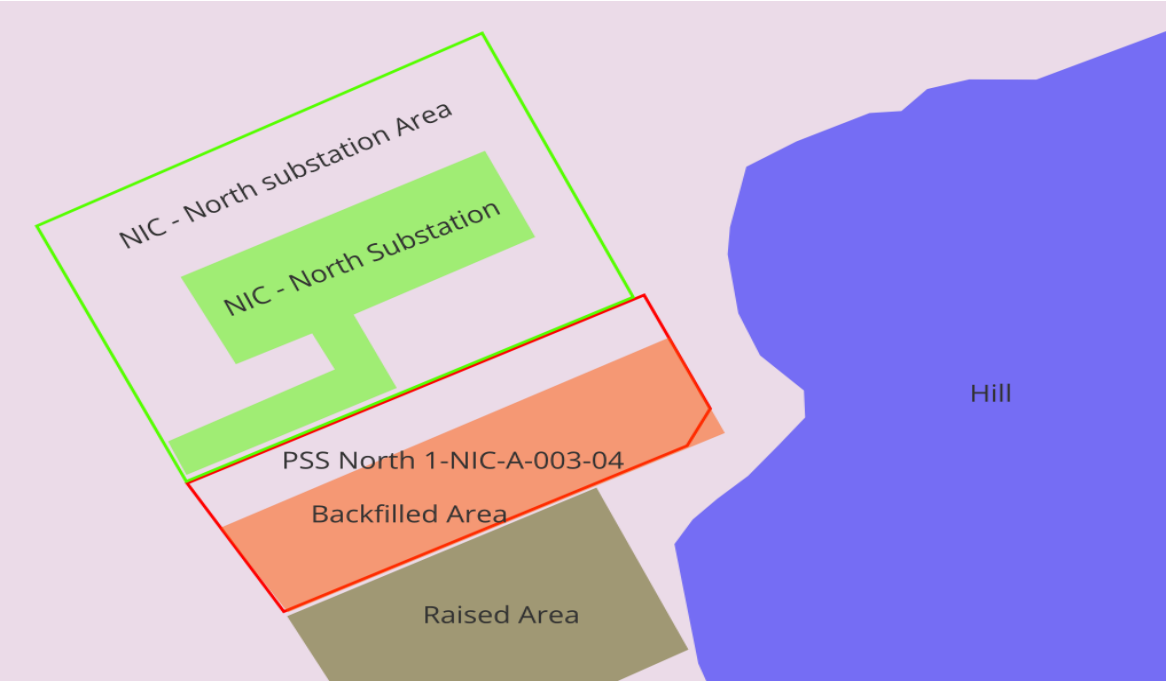

Figure 2: Indicative Layout of Site Topography for Site 1

In terms of site conditions, more than 60% of the area is covered with loosely piled excavated soil. The underlying earth appears to be soft, potentially requiring compaction or the construction of deeper foundations. No subterranean utilities were detected during the inspection, indicating a clear area for development.

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Figure 3: Site 1 - Site Conditions Snapshots

Regarding shading, there is a hill to the east of the site with an elevation of approximately 70 to 100 meters. This hill may cast shadows during the early morning hours and for a few hours following sunrise. Additionally, future developments on the elevated southern section could result in shading over the planned project area.

Furthermore, the eastern section of the land slopes towards the west with a gentle incline estimated to be between 1% and 3%. This slope, combined with runoff from the hill during heavy rainfall, poses a potential flood risk to the site. Therefore, implementing flood mitigation measures is crucial to ensure the safety and integrity of the project.

In terms of interconnection, the planned interconnection is expected to occur at the medium voltage (MV) level within the NIC North substation currently under construction. The availability of a spare feeder or bay for the purpose of interconnection is currently unknown. However, there is an unobstructed corridor between the project area and the new substation, which could be utilized for laying buried cables for routing purposes.

The site is situated approximately 680 meters from the seashore, requiring the equipment to be designed to withstand a highly corrosive environment. Additionally, a under construction substation, located about 30 meters to the south of the project site, may potentially cast shadows on a portion of the project area.

The land on the eastern side of the plot slopes down towards the west, with a gradient estimated to fall between 3 to 10%. There are also elevated areas ranging in height from 1 meter to 4 meters. Given the presence of nearby elevated areas, flood protection measures may be necessary to safeguard the site.

As part of the master plan, a topographical survey should have been done already. If proven insufficient, a topographical survey shall be conducted by an approved contractor or the DB Contractor.

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1.2 Geotechnical Survey Report

1.2.1 Site 1: NIC-A-003-04

Below are the findings regarding the existing geotechnical investigation report for the NIC-North 132/33KV Substation namely 'Geotechnical Investigation Report for Construction of NIC-North 132/33KV Substation – NEOM Project.V2' with project Id TA-22-269-SI-IN conducted by Applus SAFCO on February 19, 2023.

The LDES facility location is directly adjacent to the NIC-NORTH132/33kV Substation and therefore considering its proximity and the relatively homogeneous results of the existing geotechnical investigation, it can be concluded that this geotechnical study can be used for preliminary design purposes related to the testing facility.

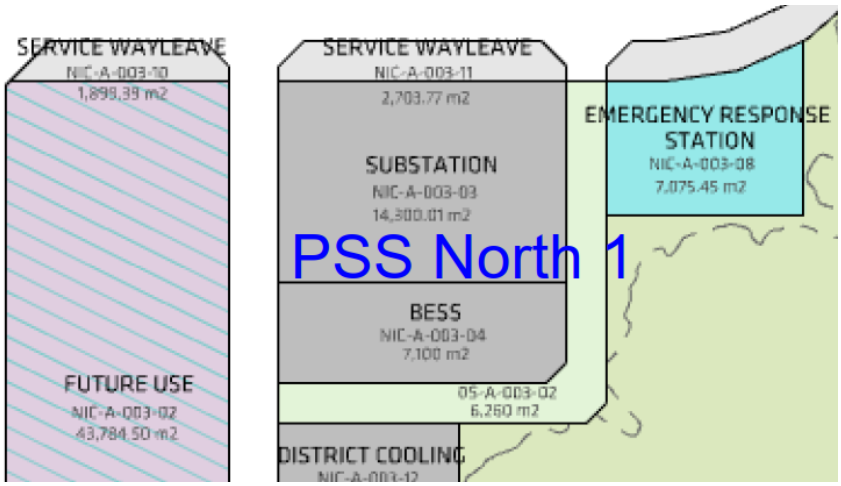

Figure 4: Plot Layout of Substation and LDES Facility Site 1

The total area of the Substation is 14 300m^2 and total area of LDES facility in Site 1 is 7 100 m^2. In general, the quality of the geotechnical study is deemed to be acceptable, and it provides the necessary level of detail to properly represent the soil conditions on site.

The geotechnical investigation comprises:

- Five (5) boreholes with following depths
  - two (2) boreholes to a depth of 15m
  - one (1) borehole to a depth of 12m
  - two (2) boreholes to a depth of 10m
- Standard Penetration Tests (SPT) at various depths in the boreholes
- Two (2) trial pits to a maximum depth of 3m / refusal
- Two (2) in situ California Bearing Ratio (CBR) tests
- Five (5) electrical resistivity tests
- Four (4) thermal resistivity tests
- Laboratory testing sieve analysis, Atterberg limits, direct shear (including bulk specific gravity and dry density of the soil), load index point, Proctor test, CBR, and chemical analysis testing to determine any potential soil/rock aggressiveness.

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The exact locations and coordinates of the different tests are hereby provided in the aforementioned report.

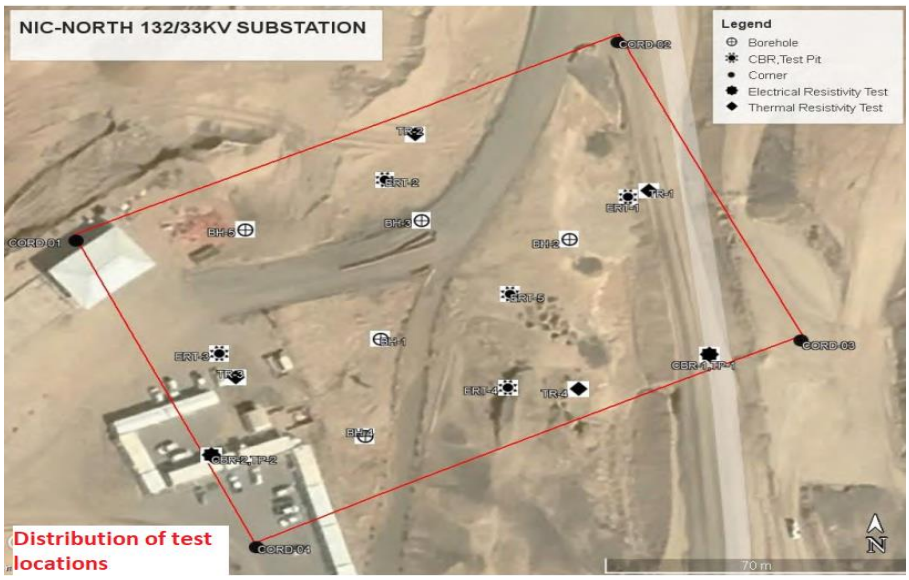

Figure 5: Test Locations- Google Earth

Based on the geotechnical investigations which were performed, the subsoil is divided into the following geotechnical units:

- Geotechnical Unit I - very dense and dry silty sand. This layer extends from ground level to depths of 0.5m and 1m at all boreholes. SPT N values range, generally, from 65 blows to 77 blows, with an approximate average of 70
- Geotechnical Unit II - very dense and dry completely weathered coral limestone (silty gravel with sand). This layer extends from depth of 1 m and extends to depth 1.5 m at boreholes BH-1 and BH-2. SPT N values were found of 100 blows
- Geotechnical Unit III - rock layer (completely to very highly weathered coral limestone interbedded with gravel). This layer was found from depths of 0.5 m and 1.5 m at all boreholes and extends to the explored depths at all boreholes.

Design soil parameters, including density, E-modulus, internal friction angle, cohesion, and earth pressure parameters, were provided for each of the Geotechnical Units as follows:

Table 32.Design Soil Parameters for Geotechnical Units I, II and III

Geotechnical Unit No.	γ (KN/m^3)	Es (MPa)	Φ (Degree)	C (KPa)	Earth Pressure Parameters		
					Ko	Ka	Kp
I	17.5	42.5	31	0	0.485	0.320	3.124
II	18.58	103.2	34	0	0.441	0.283	3.537
III	18.69	103.2	38	0	0.384	0.238	4.204

Figure 6: Design Soil Parameters for Site 1

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Groundwater was not detected in the boreholes. Additionally, no risk of cavities or soil liquefaction was identified during the investigation.

Seismic design parameters for the project were provided in accordance with the Saudi Building Code (SBC-301-AR-18), as follows:

Table 28. Project Site Seismicity

Parameter	Value (Soil)
Seismic Region	Region 1
Seismic Zone	Zone 2A
Site Class	C
PGA %	15.0
Ss.g %	40.0
S1.g %	10.0
TL	6

Figure 7: Seismic Activity for Site 1

Foundation design parameters, including allowable bearing capacity, settlement analysis and modulus of sub-grade reaction, were provided as follows:

Table 33. Bearing Capacity, Settlement Analysis and Modulus of Sub-grade Reaction

Structure	Geotechnical Unit No.	Type of Foundation	Depth of Foundation From Existing Ground level (m)	Foundation Dimensions (m)	Allowable Bearing Capacity (KPa)	Settlement (mm)	Modulus of Sub-grade Reaction (KN/m^3)
Structures which will consist of only Ground Floor without Basement	III	Spread Footing	1.5	1 m x 1 m	200	1.02	24000
				2 m x 2 m	200	2.17	24000
				3 m x 3 m	200	3.32	24000
Structures which will consist of Basement + Ground Floor and Roof Floor	III	Raft Foundation	4.2	26.305 m x 87.050 m	200	42.23	12000

Results of the two CBR tests were provided:

Table 15. Summary of In-Situ CBR Test Results

Test No.	CBR% @ Penetration 2.54mm	CBR% @ Penetration 5.08mm
CBR-1	34.1	33.3
CBR-2	27.0	24.8

Results of the electrical and thermal resistivity tests were provided:

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Table 19. Summary of Thermal Resistivity Test Results

Test No.	Sample Temperature (°C)	Moisture Content (%)	Thermal Resistivity (R) K-m/Watt	Thermal Conductivity (K) Watt/ K-m
TR-1	31.1 °C	2.50%	6.064	0.164
TR-2	31.0 °C	3.56%	6.469	0.154
TR-3	31.6 °C	3.96%	4.342	0.230
TR-4	30.1 °C	1.78%	5.765	0.173

The following laboratory tests were executed, and results were provided accordingly:

- Sieve Analysis - 13 tests
- Moisture Content - 13 tests
- Plasticity Indices - 13 tests
- Direct shear including densities - 7 tests
- Point load Strength Index - 10 tests
- Determination of the dry density/moisture content relationship of soil - 2 tests
- Determination of the California Bearing Ratio (CBR) 4-day soaked and including compaction test - 2 tests
- Chemical testing, including pH, sulphates, chlorides, and magnesium - 10 tests

The chemical analysis indicates various degree of deleterious salt (sulphates, chlorides, and magnesium) contents and based on SEC-WOA specification / standards70-TMSS-03, the exposure category of the sub-soil at the site can be classified as very severe.

Table 34. Special Exposure Condition as per SEC-WOA Specification/Standard70-TMSS-03

EXPOSURE DETAILS				MINIMUM REQUIRMENTS				
Type	Limits			Cement Type	Type of Admixture (Pozzolanic Materials)	Maximum W/BM**	Min. BM** Content (Kg/m^3)	Max. Cl In Concrete %
	Mg ppm	SO_4 ppm	CL (Soil+ Water)%					
Very Severe	>1000	>2000	>0.10	Type I C_3A-8-14%	Fly Ash	0.36	390	0.10
	<1000	>2000	>0.10	Type I C_3A-8-14%	Silica Fumes	0.40	390	0.10
Severe	>1000	>2000	>0.10	Type I C_3A-8-14%	Fly Ash	0.36	390	0.10
	<1000	>2000	>0.10	Type I C_3A-8-14%	Silica Fumes	0.40	390	0.10
	-	>2000	<0.10	Type V	Fly Ash	0.36	390	0.10
Moderate	-	<1000		Type II/Type I C_3A-8-14%	-	0.40	350	0.10
	-	1000 to <2000	<0.10	Type V	-	0.40	350	0.10

Notes:
** BM = Binding Material = Cement + Pozzolanic Materials (Fly Ash or Silica Fumes)
1. Minimum Concrete Strength- f' c 38 MPa/5500 psi for Very Severe and Severe exposure conditions.
2. Minimum Concrete Strength- f' c 28 MPa/4000 psi for Moderate exposure condition.

In order to mitigate the negative impact of deleterious salts on concrete, it is recommended that foundations, and other concrete structure coming in direct contact with the soil, shall be constructed

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using Type-I cement with C_3A content between 8% to 14% and fly ash pozzolanic material (minimum cement content equal to 390 kg/m³ and water-cement ratio should be 0.36). For the foundations, minimum cover steel of reinforcement should be 75mm. In addition, double coat of bituminous paint or waterproof membrane should be applied on concrete surface and epoxy coated reinforcement should be used. Finishing for foundations in contact with soil shall be provided for all foundations as per SEC-WOA specification / standards 70-TMSS-03.

Recommendations regarding earthworks and pavement design are also included in the report.

According to all the previous mentioned results, this study will be enough to be carried over to the tender phase.

The study can be used in order to provide the Bidders with a general overview of the area, but it is advised to request from the Geotechnical Contractor and add also borehole and trial pits logs for all test locations. Furthermore, a more precise description regarding the soil layer distribution in the different parts of the project area shall be added

1.3 Bathymetrical Survey

Not Applicable

1.4 Hydrological Survey

As this plot is part of the OXAGON master plan, a hydrological study is perceived to have been done previously. The study will be reviewed and analysed for sufficiency. If deemed insufficient, a hydrological survey shall be conducted for the project site by an approved contractor or DB contractor.

1.5 Meteorological Conditions

NEOM has a high potential for photovoltaic (PV) energy due to the high solar resource. The solar irradiation figures were taken from the Prospect database of Solargis. Prospect is a high-resolution satellite-based climate database operated by Solargis. Primary data layers include solar radiation (global horizontal irradiation and diffuse horizontal irradiation), air temperature, and terrain (elevation, horizon). For Asia, the satellite used for solar irradiation is the IODC satellite (© EUMETSAT, Germany) for the period 1999 - 2015 and with a 30-minute resolution.[1] The irradiation and meteorological data are available as monthly averages and were synthetically transposed to hourly values in the simulating software PVsyst. For atmospheric data, other satellites are used (i.e., MACC-II/CAMS, GFS, CFSR, and MERRA-2).

The envisaged location for the PV power plant in Site 1 has a moderate global horizontal irradiation of around 2,294 kWh/m² and a relatively high average annual ambient temperature of 26.2°C. The solar resource from the Prospect database of Solargis for the PV location can be seen in the below figure.

[1] https://solargis.com/support/methodology/solar-radiation-modeling/

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Figure 8: Solar resource at Site 1- Solargis Prospect

The monthly distribution of the irradiation and other meteorological data from the Prospect database is given in the table and figures below. This data represents monthly values for GHI (Global Horizontal Irradiance), DHI (Diffuse Horizontal Irradiance), DNI (Direct Normal Irradiance), and Temp (Temperature) in kWh/m2 and degrees Celsius, respectively.

The GHI values range from 119 kWh/m2 in December to 253.5 kWh/m2 in June. The Diff values range from 33.9 kWh/m2 in December to 70.3 kWh/m2 in May. The DNI values range from 176.5 kWh/m2 in December to 270.4 kWh/m2 in June. The temperature values range from 19 degrees Celsius in January to 32 degrees Celsius in August. The wind speed values range from 3.5 to 4.5 m/s.

The data also includes a yearly summary, which shows the total values for each parameter over the entire year. The total GHI for the year is 2293.8 kWh/m2, the total DHI is 612.7 kWh/m2, the total DNI is 2562.6 kWh/m2, and the average temperature is 26.2 degrees Celsius.

Table 1: Monthly Distribution of Irradiation and Temperature Data for envisaged sites

Month	GHI [kWh/m2]	Diff [kWh/m2]	DNI [kWh/m2]	Temp [deg. C]
Jan	127.9	34.8	185	19
Feb	142	40.2	176.9	20
Mar	196.6	53.5	215.9	22.3
Apr	215.1	67.7	202.7	25.3
May	241.9	70.3	229.9	28.6
Jun	253.5	55	270.4	30.7
Jul	254.2	56.2	268.5	31.5
Aug	235.3	60.4	240.3	32
Sep	203.9	52.8	218.8	30.8
Oct	170.3	51.6	193.6	28.5
Nov	134	36.2	184.1	24.5
Dec	119	33.9	176.5	20.8
Year	**2293.8**	**612.7**	**2562.6**	**26.2**

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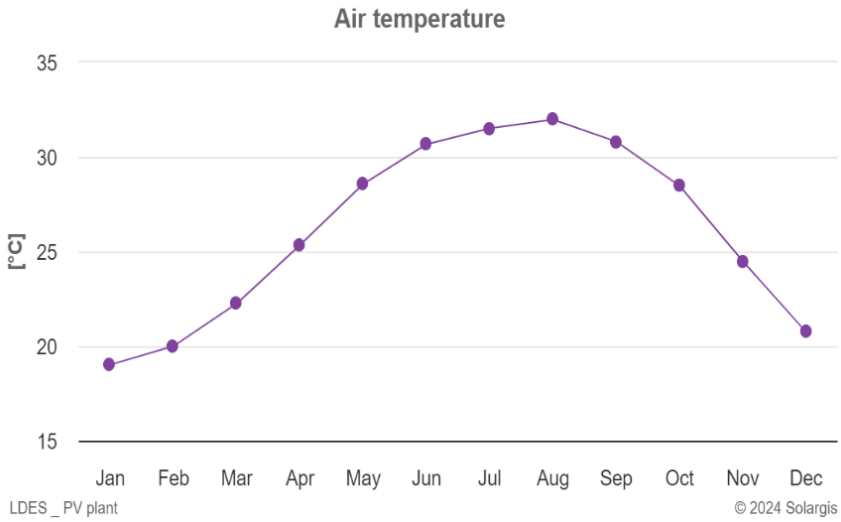

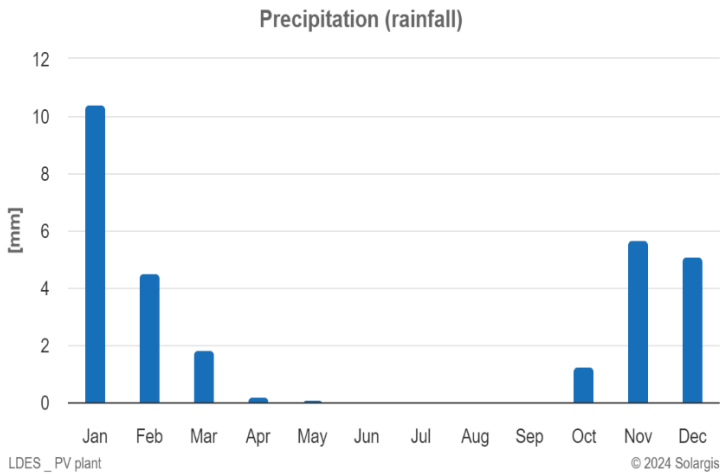

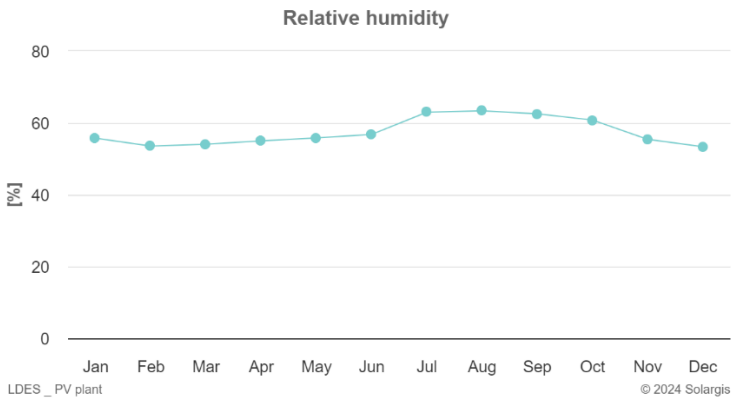

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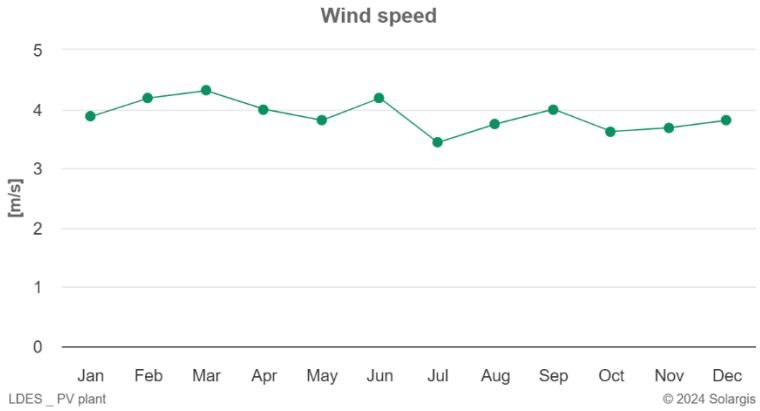

1.6 Plot Sheet Drawing

1.6.1 EES North1: NIC-A-003-04

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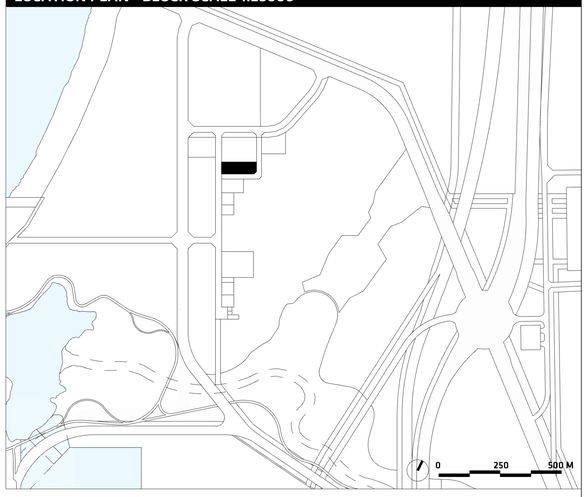
NEOM OXAGON / PLOT CONTROL PLANS

NIC-A00-003-004

OXAGON

LOCATION PLAN - OXAGON SCALE 1:100000

LOCATION PLAN - BLOCK SCALE 1:25000



PLOT DETAILS

PLOT NUMBER	NIC-A00-003-004
ASSET NAME	BESS
LAND USE / LEVEL 1	UTILITIES
LAND USE / LEVEL 2	ELECTRICAL
LAND AREA (m2)	7,100.00 m2
MAXIMUM PLOT COVERAGE	80%
ASSIGNED BUILDING FOOTPRINT	5,680.00 m2 (INDICATIVE)
ASSIGNED GFA	11,360.00 m2
ASSIGNED FAR	1.60
MAXIMUM BUILDING HEIGHT (m)	15 m
ASSIGNED NUMBER OF FLOORS	G+1 (ADDITIONAL FLOORS WHERE BUIDING HEIGHT DOES NOT EXCEED MAXIMUM BUILDING HEIGHT (m)
PLANNED NUMBER OF BASEMENT LEVELS	0

DESIGN CONTROL GUIDELINES:

1. Permitted Land Use: Please refer to the Development Control Regulations section of the OXAGON Detailed Master Plan to ensure compliance.
2. Open Space- A minimum of 20% of the total site area must be allocated to open space. Refer to DCR Vol.1 for further guidelines.
3. Parking rates per Land use-0.5:2020-2024; 0.3:2024-2027; 0.1:2027-2030; 0:after 2030/employee
4. Development Notes:
- All Government Agencies NOCs shall be obtained and all NEOM Policies and Manuals are applicable wherever necessary.
- All Plots are subject to the requirements and approvals of authorities, which may have an effect on the Plot boundary details as shown and/or requirements for electrical substations within the Plot.
- Compliance with the Controls Guidelines does not negate the need to comply with all other regulatory, statutory and permitting requirements.
- The allocated use must accord with one of the permitted or limited uses within the Use Regulations Point 1 above.
- It is advisable that plot coordinates are checked with digital file of the Plot plan.
- All dimensions and coordinates are approximate until final survey is carried out by NEOM. All dimensions indicated are in meters.
- Plot details is based on OXAGON Detailed Master Plan ref. 03-000000-1100003286-BIG-MPL-DRG-000001 Proposed Land Use and may be subject to minor changes.
- For details regarding utility connections refer to CID infrastructure drawings.

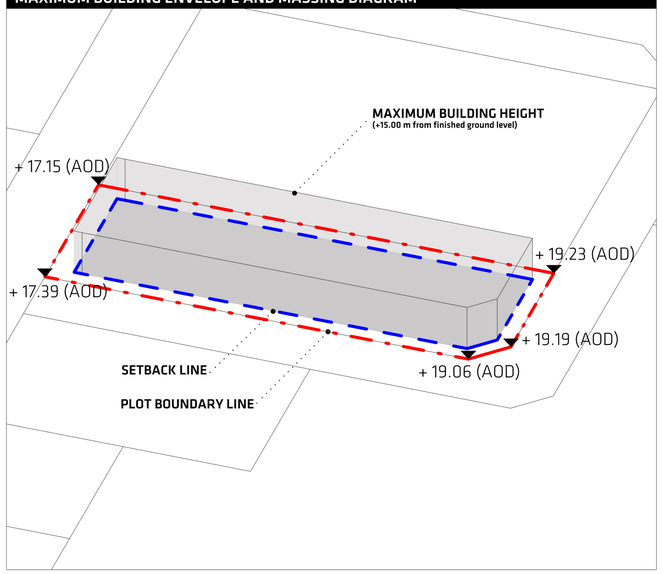
LEGEND

- PLOT BOUNDRY LINE
- SETBACK LINE
- BUILDABLE ZONE
- PLOT LOCATION
- WATER
- UTILITY CONNECTION (E-ELECTRIC W-WATER)
- SERVICE ACCESS
- VEHICULAR ACCESS
- SPOT HEIGHT AOD
- VIEW ANGLE - MASSING
- PLOT COORDINATES

PLOT COORDINATES

ID	X	Y
1	750069.503	3055254.367
2	750197.591	3055317.947
3	750215.376	3055282.118
4	750210.865	3055268.715
5	750091.733	3055209.581

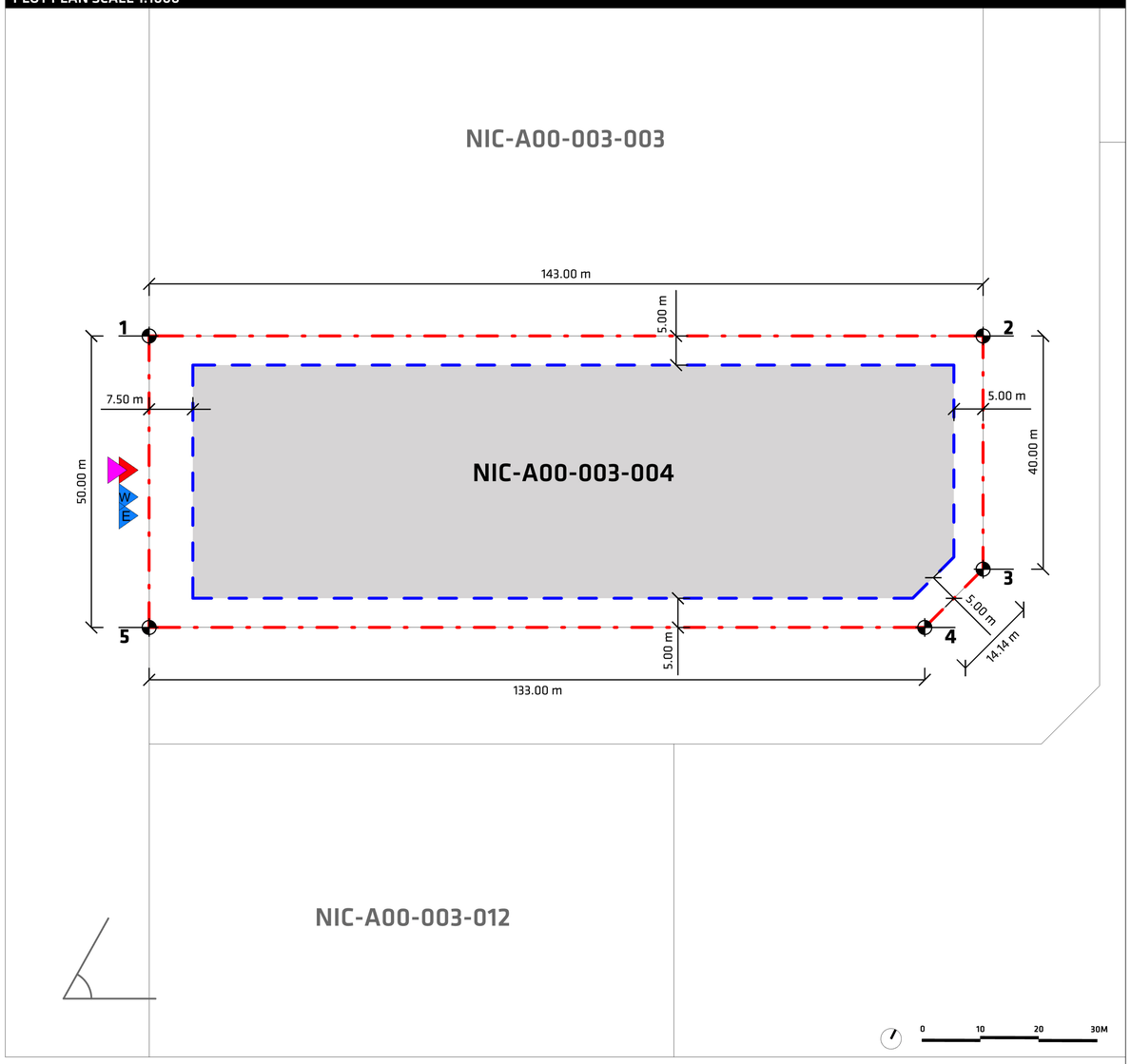
MAXIMUM BUILDING ENVELOPE AND MASSING DIAGRAM



Notes:

- All Coordinates shown are relative to UTM-WGS 84 Coordinate System
- All Elevation provided are relative to EGM-2008 Datum

PLOT PLAN SCALE 1:1000



UTILITY DEMANDS

WATER CONSUMPTION	
TOTAL DEMAND (m3/Day)	1.136
IRRIGATION DEMAND	
TOTAL DEMAND (m3/Day)	5.931
FOUL DRAINAGE	
TOTAL DEMAND (m3/Day)	1.022
POWER	
MVA	0.761

Permitting & Approvals Notes:

- All site Design approvals are the responsibility of the Plot Owner.
- This Plot sheet does not represent NEOM or where applicable KSA authority permits or approvals related to the asset Design.
- Where Environment approval / permits / ESIA are required for this asset such approvals are the responsibility of the Plot Owner / Leasee.
- The Plot Owner / Leasee may seek a deviation or relaxation from the base Plot Design controls and/or guidelines. The Owner / Leasee is to apply for the deviation or relaxation request through OXAGON's Design Team (Asset and Master Plan). Deviations and/or variations will be considered in the context of the overall Master Plan vision, objectives and desired Design and Environmental outcomes. A deviation and/or variation must not compromise the Master Plan vision, objectives and desired Design and Environmental outcomes.
- Additional floors may be considered where the building height (m) is not exceeded. If additional floors result in a greater GFA than that planned / stated in the plot sheets this will likely trigger a greater utility demand which must be considered and captured in future utility updates to the overall OXAGON Master Plan (refer to Engineering notes below).

Engineering Notes:

Utility Demands:
- All estimates are based on high level Plot typologies (light, medium and heavy industry). Plot teams to review and confirm actual demands to relevant NEOM sectors.
- Water demand benchmarks as per CMP2.0 Report Chapter 9 Water Demand (doc: 03-000000-1100002471-BHD-MPL-RPT-001009).
- Wastewater demand is based on Water Balance Methodology (90% conversion from water demand).
- Irrigation demand allows for trees around perimeter and general irrigation of non-covered area.
- Power demand benchmarks as per CMP2.0 Report Chapter 10 Energy (doc: 03-000000-1100002471-BHD-MPL-RPT-001010).
- For Industrial Plots, 10% of GFA is taken as Office Typology, 90% as Industrial Typology.
- For Utility Plots (e.g. Primary Substation), the loads are nominal for office and welfare facilities. The assigned capacity of the asset is not prescribed so as to avoid duplication.
- If the Plot Owner / Leasee requires additional utility capacity than that planned under the OXAGON Detailed Master Plan a deviation or relaxation is required. Any approved deviation and/or relaxation will result in the need for utility demand and design updates to the overall OXAGON Detailed Master Plan in a staged and coordinated manner.

Plot access:
- Plot access points are proposed via lower classification adjacent roads to reduce potential vehicle conflict points and improve capacity on higher classification roads.
- Preferences or adjustments to Plot entries should be reviewed and approved by OXAGON Development and, if relevant, the NEOM Authority.

CLIENT: NEOM OXAGON	NOT FOR CONSTRUCTION	DATE: 17/02/2024 REV: 06-D	PLOT NUMBER: NIC-A00-003-004 BESS	CONSULTANTS BIG BURO HAPPOLD